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MAF Based Shunt Active Filter Using Matlab-Simulink

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ABSTRACT

In this study, a Shunt Active Power Filter-based new control method for power distribution system current harmonic removal is proposed (ShAPF). The Phase Locked Loop (PLL) based on Moving Average Filter (MAF) is used in the control technique to enhance the dynamic response of the control circuit. The fundamental frequency and phase angle of distorted voltage and/or current signals are found using the PLL. Nevertheless, the ShAPF's control circuit's typical PLLs have a slow dynamic response. A new control strategy based on MAF with PLL is implemented for disturbance extraction from the input signals to get over this limitation. By MATLAB-based simulations, the suggested control strategy is assessed for current harmonic elimination in a power distribution system serving harmonic sensitive loads. The reduction in total harmonic distortion (THD) of the current waveform serves as evidence of the efficiency of the suggested method. Overall, the suggested method provides a successful means of removing current harmonics in power distribution systems with harmonic-sensitive loads.

INTRODUCTION

Modern society is strongly reliant on the availability of electricity because it is the most common and efficient kind of energy. The existence without the availability of electricity is unimaginable. In addition, the calibre of the electricity delivered is crucial for the effective operation of the end user equipment.

The term "power quality" has gained a lot of traction in the energy industry, and both the end-users and the electric power supply firm are worried about it. The article examines the significance of power quality, which is the deviation of the provided electric power's voltage and frequency ranges from the benchmark values.

Semiconductor technology has advanced to the point that they are now a commonplace in the power industry. The devices, however, draw non-linear current from the source because of their non-linear nature.

Due to the numerous switching operations that conversion involves, there are harmonics present, which have an impact on the quality of the power delivered to the end consumer. In order to solve the issues brought on by harmonics, filters are used. The literature contains a variety of filter topologies for this use, including active, passive, and hybrid filters. Yet, when used to enhance power quality, active filters have several limitations. A hybrid power filter, which combines active and passive filters, is suggested as a solution to these problems. The article also covers several control strategies that active filters can use to inject a voltage into the system that offsets harmonics. The essay comes to the conclusion that the creation of harmonics, which degrades the quality of electricity and may destroy end-user equipment, is the key issue affecting the sensitivity of equipment. Harmonics must be removed through the use of a filtering device in order to maintain the quality of the transmitted electricity. A differential protection strategy is used to detect power theft. Energy is a critical component of growth in Nigeria, and effective, dependable, and environmentally friendly energy sources, transmission, and distribution are required to promote development. This significantly increases the pressure on power companies to offer customers high-quality energy services.

LITERATURE SURVEY

Making educated decisions on transmission lines requires methodologies for asset inventory that are precise, effective, and economical. There are many different filter topologies, including active, passive, and hybrid ones. This project will study and analyse hybrid filter topologies in order to enhance the quality of the electric power. Filters are used to reduce problems caused by harmonics, and several filter topologies can be discovered in the literature. Initially, passive filters were used, but they only worked well for removing certain frequency harmonics and were highly parameter sensitive, causing resonance problems with the system impedance. Active filters were established in the 1970s to account for reactive power and negative sequence currents in order to get around these restrictions. In a research study, active filter configurations and control methods are reviewed along with the usage of active power filters for improving power quality. However, there are still significant disadvantages to active filters, including the need for high converter ratings, the higher cost compared to passive filters, the bigger size, and the increased losses. In a research study, a hybrid power filter that includes both active and passive filters is suggested to address the shortcomings of active and passive filters. The study explains how this remedy is a cost-effective means of enhancing power quality.

There are various control strategies available for properly controlling the active filter.

The instantaneous reactive power theory is found to be a more effective control strategy, with vectorial-based theory outperforming other algorithms when used with sinusoidal currents. Deviations in voltage, current, or frequency have an impact on power quality and can cause issues like power surges, transients, electrical line noise, brownouts or blackouts, power system faults, and improper grounding, which result in harmonics that degrade power quality and can harm end-user equipment. Moreover, harmonics can result in problems including underground cable heating, insulation failure, shortened equipment lifetime, and increased losses.

PROBLEM IDENTIFICATION

APFs do have several disadvantages, too, including more cost than passive filters, larger size and losses, and higher converter ratings. A hybrid power filter that combines active and passive filters has been suggested as a way to get around these restrictions. This hybrid filter enhances the qualities of passive filters and boosts system efficiency, making it a cost-effective way to improve power quality.

The effective operation of the hybrid filter depends on the active filter being properly controlled. The active filter is frequently managed using the instantaneous reactive power theory. This theory provides many control methods for reaching the active filter's target output voltage, which corrects for harmonics. Using sinusoidal currents, it is discovered that the vectorial-based theory performs superior to other algorithms.

Many issues, including power surges, transients, frequency changes, electrical line noise, brownouts or blackouts, power system defects, and poor grounding, have an impact on the quality of the electricity. These issues result in harmonics, which lower the quality of the power and harm end-user devices. Filters can be used to reduce the impacts of harmonics and enhance the quality of the electricity. A hybrid filter combines the benefits of passive and active filters to improve power quality more effectively and cost-effectively. A passive filter can remove high order harmonics and create a low impedance channel for the fundamental frequency in a hybrid filter. On the other hand, the active filter part can provide reactive power compensation and make up for any leftover harmonics.

In comparison to utilising solely an active filter, the converter rating and size can be decreased by using a hybrid filter. In addition, compared to passive filters, the hybrid filter can manage a larger variety of load situations and is less sensitive to changes in system parameters. In general, using a hybrid filter can result in a big improvement in power quality and a decrease in losses and equipment damage.

METHODOLOGY

For the purpose of harmonic abatement in low and medium voltage power distribution networks, the shunt hybrid APF topology combines active and passive filters. A three-phase shunt active filter (SAF) and tuned passive filters (TPF)

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are linked in parallel with the load in this design, which is based on a voltage source inverter (VSI).

The modelling of the shunt active filter as well as the design of the filter interfacing inductor, DC bus capacitor, and tuned passive filters must be taken into account when designing the shunt hybrid APF topology. Calculating the load current, the DC bus voltage and current, and the current reference for the SAF are all necessary steps in the modelling of the shunt active filter. The design of the DC bus capacitor and filter interface inductor rely on the system's power rating, whereas the design of tuned passive filters depends on the harmonics that need to be reduced.

The estimation of the compensatory reference current for the SAF is done using the analysis of the synchronous reference frame theorem. The three-phase voltage and current signals must be transformed into the synchronous reference frame, where the AC signal is, in order to prove the theorem.

Overall, the shunt hybrid APF topology provides low and medium voltage power distribution systems with a successful method of harmonic suppression.

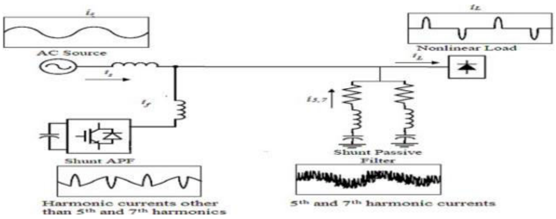

Fig.1.1: The proposed Shunt Hybrid APF's operating principle.

Harmonic compensation is the basis for how the shunt hybrid APF architecture functions. The nonlinear load is connected in parallel with the tuned passive filters, which are designed to absorb certain harmonic currents. The shunt active filter (SAF), which compensates for the remaining harmonics, creates a compensation current that is identical to the harmonic load current but in the opposite phase, injecting it through an interface inductor into the point of common coupling (PCC). A capacitor attached to the DC side of the SAF, a voltage source inverter (VSI), serves as a storage element.

The compensation current produced by SAF must be identical in amplitude and phase to the harmonic load current in order to provide a sinusoidal and in-phase source current. The compensatory reference current is estimated using a synchronous reference frame theorem. The VSI uses switching signals produced by the hysteresis current controller to inject the compensation current into the PCC. The SAF's size and cost are decreased by the TPFs, which use the series resonance principle to absorb certain harmonic currents. Overall, the shunt hybrid APF design offers an excellent solution for harmonic suppression in low and medium voltage power distribution systems. The SAF works by removing harmonics by injecting a compensating current (if) in parallel with the nonlinear load current (iL). A VSI that is regulated by a current controller to ensure that the injected current is equal to the harmonic current of the load but in the opposite phase produces the compensatory current.

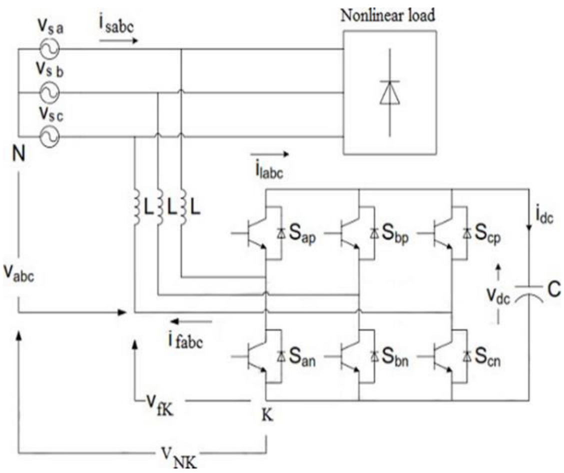

Fig. 1.2: Three phase shunt active filter strategy.

IMPLEMENTATION

(MAF-PLL) to get the shunt filter's control signal. In comparison to conventional PLLs, the MAF-PLL has the advantages of less computational complexity and greater accuracy. The suggested control strategy has a response time of less than 10 ms and can reduce harmonics up to the 50th order. The outcomes of the simulation demonstrate that the suggested control strategy efficiently lowers harmonic distortion in the load current and raises the system's power factor.

The proposed control scheme is capable of mitigating harmonics up to 50thorder with a response time of less than 10 ms.

The output of the simulation results suggest that the control scheme effectively reduces harmonic distortion in the load current and enhance the power factor of the system.

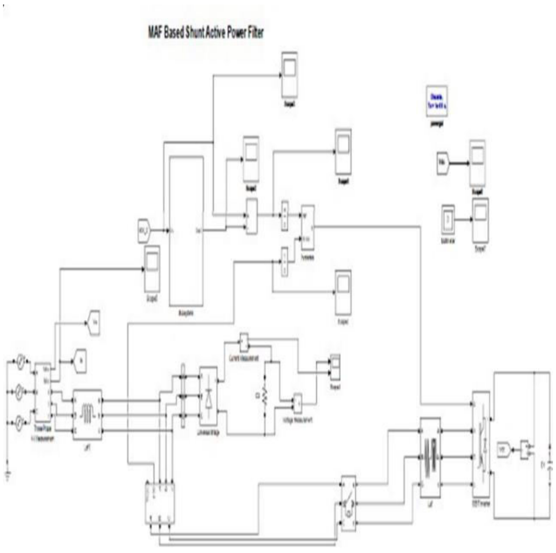

Figure 2.1: Shunt power filter schematic in MATLAB.

RESULTS AND CONCLUSIONS

Figures 2.2–2.8, respectively, show the current supplied by the shunt active filter and the resonant filter, as well as the current supplied by the source and the load.

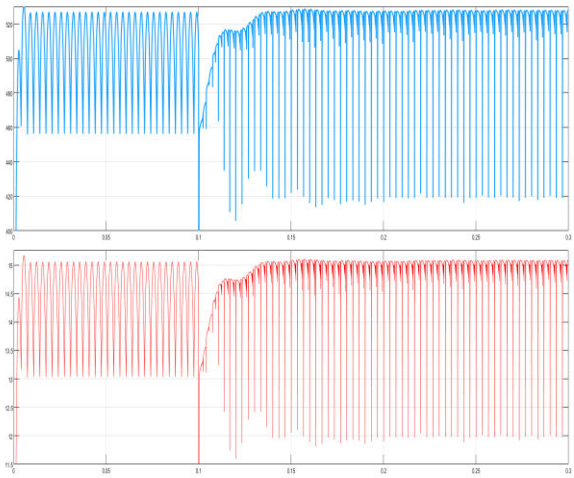

Figure 2.2: voltage and current at the load.

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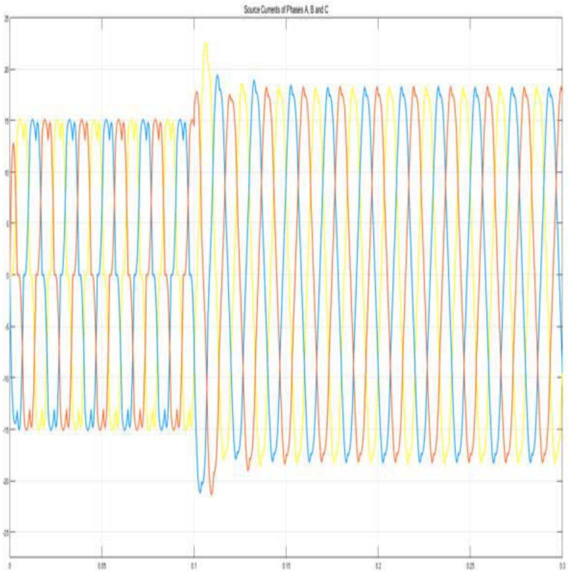

Figure 2.3: Source currents for phases A, B and C are shown.

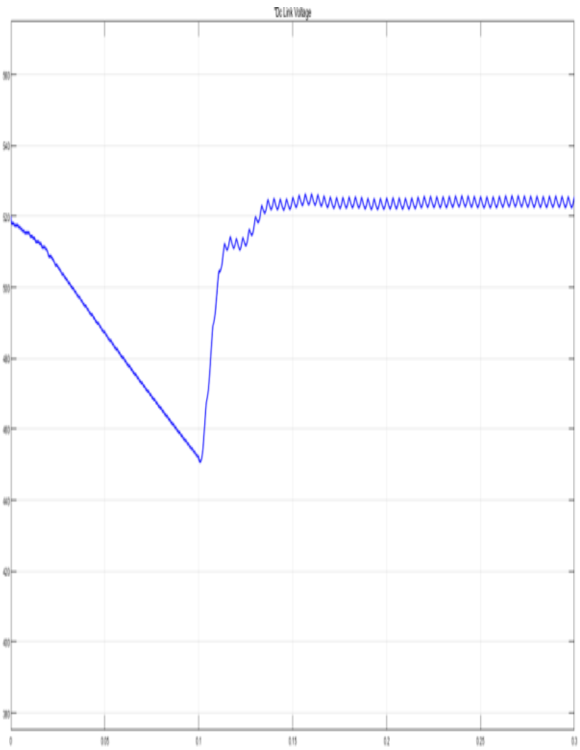

Figure 2.4: DC line voltage is shown.

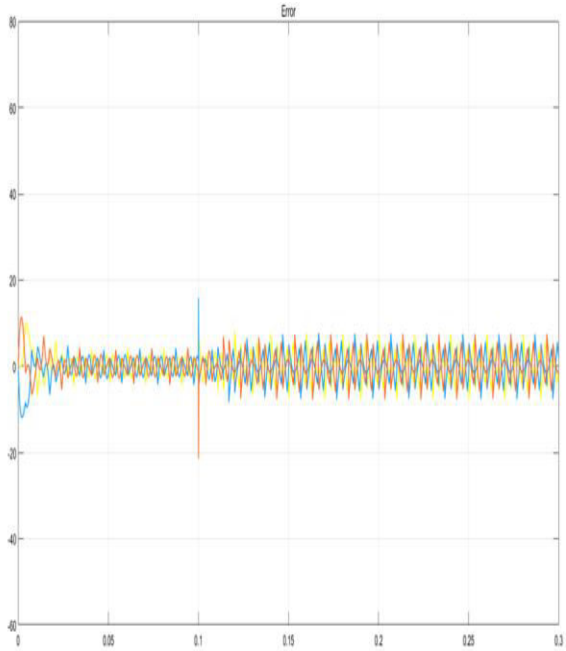

Figure 2.5: Error is shown

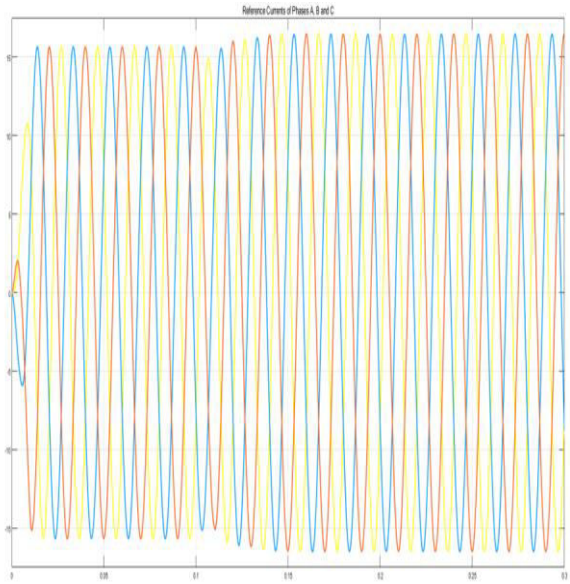

Figure 2.6: phases A ,B and C reference currents are shown.

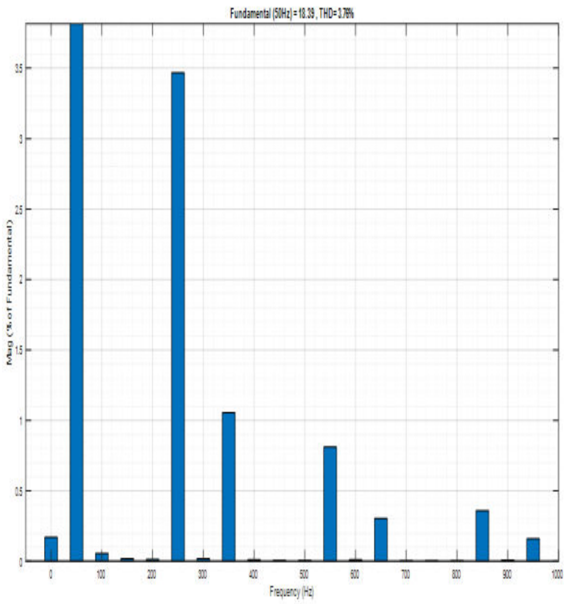

Figure 2.7: THD = 3.76%,fundamental frequency of 50Hz=18.30.

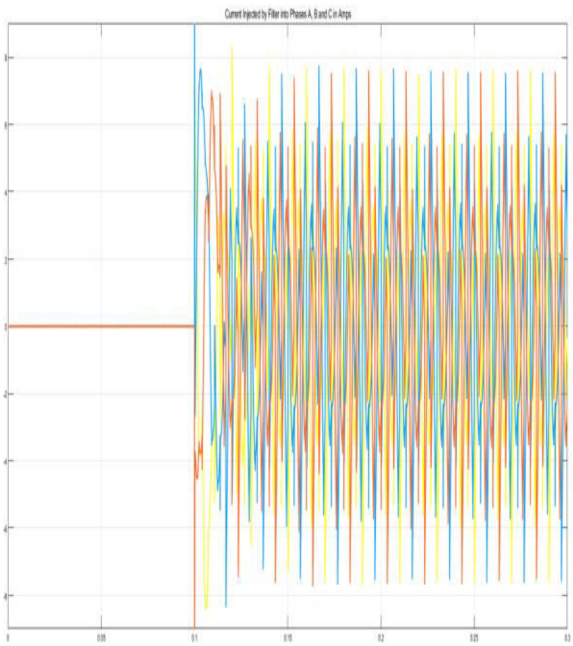

Figure 3.7: It shows the current that a filter injects into phases A, B and C.

>>Conclusion

In order to remove current harmonics from distorted utility currents and keep THD within the limitations, the MAF-PLL based current control method for a ShAPF appears to be effective.

By injecting an equal but opposing current to cancel out the harmonic currents in the system, an active harmonic filter (AHF), a type of power electronic device, can reduce harmonic distortion in power systems. The AHF is a real-time device that can be used to correct harmonic, interharmonic, and notching effects brought on by nonlinear loads. The AHF successfully cancels out the harmonic distortion and maintains a sinusoidal waveform of the current by injecting the opposite current. It's wonderful to learn that by integrating many control tasks into a single device, current AHFs can handle a number of power quality issues and aid in the advancement of clean energy. This can undoubtedly aid in the transition to a more sustainable and clean energy system.

LIMITATIONS AND FUTURE SCOPE

By infusing a distorted current with the same magnitude but the opposite phase into the electrical power system in real-time, active harmonic filters (AHF) can remove waveform distortions caused by loads like harmonics, interharmonics, and notching. They can also serve as harmonic generators for testing harmonic injection. By integrating many control tasks into a single device, modern AHFS may address a number of power quality issues and aid in the development of clean energy.

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